



IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: Smith et al

Patent No.: 7,088,427
Issued: August 8, 2006

Serial No.: 10/828,579
Filed: April 20, 2004

Conf. No.: 5263
Customer No.: 33123

For: APPARATUS AND METHOD FOR HIGH
RESOLUTION IN-SITU ILLUMINATION
SOURCE MEASUREMENT IN
PROJECTION IMAGING SYSTEMS

Art Unit: 2851

Examiner: V. Nelson

CERTIFICATE OF MAILING

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Date

Signature

Certificate
SEP 13 2006
of Correction

**REQUEST FOR CERTIFICATE OF CORRECTION
PURSUANT TO 37 C.F.R. § 1.322**

Attn: Certificate Of Correction Branch
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

Pursuant to 37 C.F.R. § 1.322, the patentee respectfully requests that a Certificate of Correction be issued for the above-referenced patent.

REMARKS

A Certificate of Correction (Form PTO-1050), in duplicate, is included with this Request. The errors appear to be that of the USPTO, and it is believed no fee is due. If it is determined that a fee is due, the Office is hereby authorized to charge the fee to Deposit Account No. 50-1213.

This Certificate of Correction seeks to correct obvious typographical and grammatical errors in the specification of the issued patent. During prosecution, a "Preliminary Amendment" was filed on August 26, 2004 (copy enclosed). The return postcard was received from OIPE

SEP 13 2006

Applicant: Smith et al

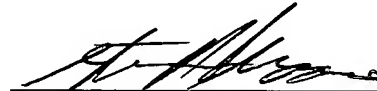
Patent No. 7,088,427 - Issued: August 8, 2006

REQUEST FOR CERTIFICATE OF CORRECTION

indicating that the Preliminary Amendment was received on August 30, 2005. The amendments to specification from the Preliminary Amendment are not reflected in the printed patent.

No new matter has been added. Approval of the proposed correction and issuance of the Certificate of Correction are respectfully requested.

Respectfully submitted,
Heller Ehrman LLP



Steven A. Moore
Registration No. 55,462

Attorney Docket No. 38203-6294

Address all correspondence to:

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SD 833810 v1 (38203.6294)

UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

Page 1 of 2

PATENT NO. : 7,088,427
 APPLICATION NO. : 10/828,579
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It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

IN THE SPECIFICATION

Column 1, line 61 to column 2, line 25, please amend as follows:

--The effect of the illumination source (~~source~~) when coupled to projection imaging objective (PIO, or lens that relay the reticle object plane to the wafer plane) aberrations has been documented, as has the deleterious effects of improperly or non-optimally configured sources themselves on lithographic printing. See, for example, "Differences of Pattern Displacement Error Under Different Illumination Conditions", N. Seong et al., *SPIE*, Vol. 3334, 868:872, 1998; "Effect of Off-Axis Illumination on Stepper Overlay", N. Farrar, *SPIE*, Vol. 2439, 273:275, 1995; "Overlay Error Due to Lens Coma and Asymmetric Illumination Dependence", H. Nomura et al., *SPIE*, Vol. 3332, 199:210, 1998; and see "The Effects of an Incorrect Condenser Lens Setup on Reduction Lens Printing Capabilities", D. Peters, *Interface 85*, Kodak Publ. No. G-154, 66:72, 1985; "Impact of Local Partial Coherence Variations on Exposure Tool Performance", Y. Borodovsky, *SPIE*, Vol. 2440, 750:770, 1995; "Condenser Aberrations in Kohler Illumination", D. Goodman et al., *SPIE*, Vol. 922, 108:134, 1988; "Mathematical Treatment of Condenser Aberrations and their Impact on Linewidth Control", C. Krautschik et al., *Intel*, 1:12, 1998; "Examples of Illumination Source Effects on Imaging Performance", A.J. deRuyter et al., *ARCH Chemicals Microlithography Symposium*, 2003. Comprehensive modeling will generally require knowing the radiant intensity across the projection field, machine settings, and machines. See, for example, "Understanding Systematic and Random CD Variations using Predictive Modeling Techniques", D. Flagello et al., *SPIE*, Vol. 3679, 162:175, March 1999; "Understanding Across Chip Line Width Variation: The First Step Toward Optical Proximity Correction", L. Liebmann et al., *SPIE*, Vol. 3051, 124:136, 1997.--

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This collection of information is required by 37 CFR 1.322, 1.323, and 1.324. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1.0 hour to complete, including gathering, preparing, and submitting the completed application for to the USPTO. Time may vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Attention Certificate of Corrections Branch, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

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Column 6, lines 4-9, please amend as follows:

--Another design point, referring to FIG. 1, with a chrome opening CO in a chrome coating on the reticle face RF, is large enough to allow the entire source as represented by the marginal imaging point MIP of FIG. 5 to pass. One of the main ~~reason~~ reasons for keeping some chrome coating is to reduce stray light reflection off of the reticle.--

Column 10, lines 50-67, please amend as follows:

--When recording the source images in photoresist on a wafer, the process flow of FIG. 19 is used. First an MFISIO as described herein is provided and loaded onto the machine we are characterizing. Next a resist coated substrate (wafer) is provided and loaded on the machine. Next, the substrate is exposed at multiple, increasing exposure doses at discretely separated image fields on a ~~wafer~~ wafer. See, for example, page 3 of "Examples of Illumination Source Effects on Imaging Performance" by A.J. de Ruyter et. al. in 2003 ARCH Chemicals Microlithography Symposium, *supra*. The substrate is then developed and the exposed images are photographed one by one. From these images and knowledge of the exposure dose sequence, the 'raw' intensity contours of $\frac{dE}{do}(nx, ny)$ are obtained. Next these intensity contours are computationally overlapped and the radiometric and the exit pupil transmission correction factor (Equation 4) are applied to reconstruct the normalized radiant intensity (FIG. 21):--

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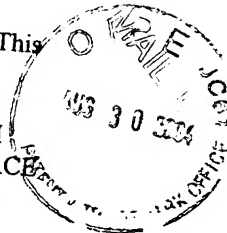
Client #: 38203-6294 (DAH:ark)

Enclosures: Preliminary Amendment, 14 pages; This
Postcard.

For: APPARATUS AND METHOD FOR HIGH
RESOLUTION IN-SITU ILLUMINATION SOURCE
MEASUREMENT IN PROJECTION IMAGING
SYSTEMS

Applicant(s): A. Smith et al.

Application No.: 10/828,579 - Filed: 04/20/2004



SEP 13 2006



IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant(s): Smith et al.
Serial No.: 10/828,579
Filed: April 20, 2004
Customer No.: 33123
For: **APPARATUS AND METHOD
FOR HIGH RESOLUTION IN-
SITU ILLUMINATION SOURCE
MEASUREMENT IN
PROJECTION IMAGING
SYSTEMS**
Art Unit: 2878
Examiner: Not yet assigned

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PURSUANT TO 37 CFR 1.8

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Michelle Melendy
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PRELIMINARY AMENDMENT

Commissioner for Patents
PO Box 1450
Alexandria, VA 22313-1450

Sir:

Preliminary to the examination of the above-identified application, please enter the following amendment and consider the following remarks.

Amendments to the specification begin on Page 2 of this document.

Amendments to the claims begin on Page 5 of this document.

Remarks begin on Page 14 of this document.

SEP 13 2006

IN THE SPECIFICATION

Please amend the specification as follows. Paragraphs that are being amended are listed in their entirety; changes are indicated in the left margin with a vertical change bar. Deletions are marked by ~~strike through~~; insertions are underlined.

Please amend the paragraph on page 1, line 20 through page 3, line 10, as follows:

Presently lithographers adjust the properties of the illumination source (partial coherence, annularity, etc.) to increase the useable processing window. See, for example, "High Throughput Wafer Steppers with Automatically Adjustable Conventional and Annular Illumination Modes", J. Mulken ~~et al.~~ et al. As used herein, "illumination source" means the collective effect of the pre-reticle optics (such as mirrors, homogenators, lenses, polarizers, diffusers, etc.) and the light source (mercury arc lamp, excimer laser, synchrotron radiation, etc.) on creating a radiant intensity pattern (energy per unit solid angle) at the reticle. For Kohler Illumination (see, for example, "Principles of Optics", M. Born et al., *Pergamon Press*, 524:526), the source on a particular machine, and for a particular machine setting, is completely characterized by the radiant intensity given by:

$$\frac{dE}{d\Omega}(n_x, n_y; x, y) = \text{energy per unit solid angle coming from direction } (n_x, n_y) \text{ and} \\ \text{at transverse spatial position } (x, y) \text{ on the reticle} \quad (\text{Eq. 1}).$$

The ability to predict lithographic performance, especially cross-field or machine to machine variation, is contingent on quantitatively knowing the factors causing

variation and this includes the illumination source $\left(\frac{dE}{d\Omega} \text{ of Equation 1} \right)$. The effect of the

illumination source ~~(source)~~ when coupled to projection imaging objective (PIO, or lens that relay the reticle object plane to the wafer plane) aberrations has been documented,

as has the deleterious effects of improperly or non-optimally configured sources themselves on lithographic printing. See, for example, "Differences of Pattern Displacement Error Under Different Illumination Conditions", N. Seong et al., *SPIE*, Vol. 3334, 868:872, 1998; "Effect of Off-Axis Illumination on Stepper Overlay", N. Farrar, *SPIE*, Vol. 2439, 273:275, 1995; "Overlay Error Due to Lens Coma and Asymmetric Illumination Dependence", H. Nomura et al., *SPIE*, Vol. 3332, 199:210, 1998; and see "The Effects of an Incorrect Condenser Lens Setup on Reduction Lens Printing Capabilities", D. Peters, *Interface 85*, Kodak Publ. No. G-154, 66:72, 1985; "Impact of Local Partial Coherence Variations on Exposure Tool Performance", Y. Borodovsky, *SPIE*, Vol. 2440, 750:770, 1995; "Condenser Aberrations in Kohler Illumination", D. Goodman et al., *SPIE*, Vol. 922, 108:134, 1988; "Mathematical Treatment of Condenser Aberrations and their Impact on Linewidth Control", C. Krautschik et al., *Intel*, 1:12, 1998; "Examples of Illumination Source Effects on Imaging Performance", A.J. deRuyter et al., *ARCH Chemicals Microlithography Symposium*, 2003. Comprehensive modeling will generally require knowing the radiant intensity across the projection field, machine settings, and machines. See, for example, "Understanding Systematic and Random CD Variations using Predictive Modeling Techniques", D. Flagello et al., *SPIE*, Vol. 3679, 162:175, March 1999; "Understanding Across Chip Line Width Variation: The First Step Toward Optical Proximity Correction", L. Liebmann et al., *SPIE*, Vol. 3051, 124:136, 1997.

Please amend the paragraph beginning on page 5, line 7, as follows:

Figure 5 shows a ray trace diagram for ISIO of the first main ~~embodiment~~
embodiment.

Please amend the paragraph beginning on page 9, line 20, through page 10, line 2, as follows:

Another design point, referring to Figure 1, with a chrome opening CO in a chrome coating on the reticle face RF, is large enough to allow the entire source as represented by the marginal imaging point MIP of Figure 5 to pass. One of the main ~~reason~~ reasons for keeping some chrome coating is to reduce stray light reflection off of the reticle.

Please amend the paragraph beginning on page 5, lines 6-20, as follows:

When recording the source images in photoresist on a wafer, the process flow of Figure 19 is used. First an MFISIO as described herein is provided and loaded onto the machine we are characterizing. Next a resist coated substrate (wafer) is provided and loaded on the machine. Next, the substrate is exposed at multiple, increasing exposure doses at discretely separated image fields on a wafer wafer. See, for example, page 3 of "Examples of Illumination Source Effects on Imaging Performance" by A.J. de Ruyter et. al. in 2003 ARCH Chemicals Microlithography Symposium, *supra*. The substrate is then developed and the exposed images are photographed one by one. From these images and knowledge of the exposure dose sequence, the 'raw' intensity contours of $\frac{dE}{do}(nx, ny)$ are obtained. Next these intensity contours are computationally overlapped and the radiometric and the exit pupil transmission correction factor (Equation 4) are applied to reconstruct the normalized radiant intensity (Figure 21):

$$R(nx, ny; x, y) = \frac{1}{N} \frac{dE}{do}(nx, ny; x, y) \quad (\text{Equation 10})$$

where:

$$N = \int_{do_n} \frac{dE}{do}(nx, ny; x, y) \quad \text{the normalization} \quad (\text{Equation 11})$$

LISTING OF CLAIMS

This listing of claims will replace all prior versions and listings of claims in this patent application:

1. (original) An apparatus for measuring radiant intensity of a photolithographic illumination source in a photolithography projection imaging system, the apparatus comprising:

a plurality of discrete imaging objectives, each capable of imaging to a corresponding field point, thereby imaging a plurality of field points; and
a common imaging surface for the plurality of discrete imaging objectives, wherein each of the plurality of field points is imaged on the common imaging surface; wherein the discrete imaging objectives have sufficient resolution to permit reconstruction of a radiant intensity profile of the illumination source.

2. (original) The apparatus as defined in Claim 1, wherein the intensity profile is reconstructed from measurement of radiant intensity at the field points.

3. (original) The apparatus of Claim 1, wherein one or more of the discrete imaging objectives comprises a plano convex lens.

4. (currently amended) The apparatus of Claim 1, wherein one or more of the discrete imaging objectives comprises a computer generated hologram element.

5. (original) The apparatus of Claim 1, wherein one or more of the discrete imaging objectives comprises an aspherically corrected lens.

6. (original) The apparatus of Claim 1, wherein one or more of the discrete imaging objectives comprises a computer generated hologram integral with a reticle top surface.

7. (original) The apparatus of Claim 1, wherein one or more of the discrete imaging objectives comprises a micro imaging objective.
8. (original) The apparatus of Claim 1, wherein one or more of the discrete imaging objectives comprises a multi-element imaging objective.
9. (original) The apparatus of Claim 1, wherein one or more of the discrete imaging objectives comprises a reflective computer generated holographic plate.
10. (original) The apparatus of Claim 1, wherein said common imaging surface comprises a reticle face.
11. (original) The apparatus of Claim 1, wherein said common imaging surface comprises a plane located beyond a reticle face.
12. (original) The apparatus of Claim 1, wherein said common imaging surface comprises a plane located before a reticle face.
13. (original) The apparatus of Claim 1, wherein the discrete imaging objectives fit within a reticle/pellicle envelope.
14. (original) The apparatus of Claim 1, wherein the discrete imaging objectives can be placed in an illuminator beamtrain such that the common imaging surface lies at a reticle conjugate imaging plane.
15. (currently amended) The apparatus of ~~Claim 1~~ Claim 1, further comprising a common mounting for the plurality of imaging objectives.

16. (original) The apparatus of Claim 15, wherein the common mounting comprises a projection imaging tool.

17. (original) The apparatus of Claim 15, wherein the common mounting comprises a support plate.

18. (original) The apparatus of Claim 1, wherein the discrete imaging objectives can be placed in an illuminator beamtrain such that the common imaging surface lies at a reticle conjugate imaging plane.

19. (original) A projection imaging system comprising:
an illuminator comprising a light source that generates a radiant intensity profile and produces an illuminator beamtrain;
a multiple field imaging objective in optical communication with the light source;
a projection imaging optic distal the multiple field imaging objective; and
an electronic sensor array, wherein the multiple field imaging objective images the radiant intensity profile onto a plane optically conjugate to the electronic sensor array via the projection imaging optic with sufficient resolution to permit reconstruction of the radiant intensity profile.

20. (currently amended) The apparatus of ~~Claim 19~~ Claim 19, further comprising a reticle table that separates a reticle from the projection imaging optic.

21. (original) The apparatus of Claim 19, wherein the electronic sensor array comprises an imaging optic that relays the plane to the sensor array.

22. (original) The apparatus of Claim 19, wherein multiple field imaging objective comprises a reticle having one or more computer generated holograms written on its face.

23. (currently amended) A projection imaging system comprising:
an illuminator comprising a light source, a reflective substrate, and a reflective reticle, wherein the light source projects a plurality of light rays toward the reflective substrate, which reflects the light rays toward the reflective reticle; and
a multiple field imaging objective in optical communication with the reflective reticle, wherein the plurality of rays are incident on the multiple field imaging objective;
wherein the multiple field imaging objectives have sufficient resolution to permit reconstruction of a radiant intensity profile of the illumination ~~source.~~ source.
24. (original) The projection imaging system of Claim 23, wherein the source image lies in a plane distal to the reticle.
25. (original) The projection imaging system of Claim 23, wherein the reflective substrate comprises a folding mirror.
26. (original) The projection imaging system of Claim 23, wherein the reflective substrate comprises one or more computer generated holograms.
27. (original) The projection imaging system of Claim 26, wherein the reflective substrate comprises at least two computer generated holograms separated by one or more non-reflective regions.
28. (original) The projection imaging system of Claim 23, wherein the reflective reticle comprises a reflective coating with modulated reflectivity.
29. (original) A projection imaging system comprising:
an illuminator comprising a light source, a reflective substrate, and a reflective reticle, wherein an illuminator beamtrain is projected toward the reflective substrate that

includes a multiple in-situ imaging objective, and is reflected toward the reflective reticle;
and

a common imaging surface where the radiant intensity of the beamtrain is
recorded at multiple field points;

wherein the multiple in-situ imaging objectives have sufficient resolution to permit
reconstruction of a radiant intensity profile of the illuminator.

30. (original) A projection imaging system as defined in Claim 29, wherein the in-situ
imaging objective is a computer generated hologram.

31. (original) A projection imaging system as defined in Claim 29, wherein the in-situ
imaging objective is an asphere.

32. (original) A projection imaging system comprising:
a multiple field imaging objective;
an aperture blade located at a distance that coincides with a reticle conjugate
imaging plane associated with the multiple field imaging objective;
a source relay in optical communication with the multiple field imaging objective;
and
a reticle;

wherein the source relay optic images the multiple field objective image formed
at the reticle conjugate imaging plane onto the reticle with sufficient resolution to permit
reconstruction of a radiant intensity profile of an illuminator.

33. (original) The projection imaging system of Claim 32, wherein the multiple field
imaging objective comprises multiple elements.

34. (original) A projection imaging system comprising:
a multiple field imaging objective located so that the imaging surface of the multiple field imaging objective coincides with a conjugate imaging plane of a reticle;
an aperture blade located at the reticle conjugate imaging plane;
a source relay optic in optical communication with the reticle so as to relay images of the multiple field imaging objective formed at the reticle conjugate imaging plane onto a substrate with sufficient resolution to permit reconstruction of a radiant intensity profile of an illuminator.
35. (original) The projection imaging system of Claim 34, wherein the multiple field imaging objective comprises multiple elements.
36. (original) A process for measuring the radiant intensity of an illuminator beamtrain in a projection lithography tool comprising:
loading a multiple field in-situ imaging objective with sufficient resolution to permit reconstruction of a radiant intensity profile of an illuminator into the projection lithography tool;
exposing a recording substrate to multiple doses of light through the in-situ imaging objective;
developing the substrate and measuring the substrate to determine exposed regions versus dose; and
reconstructing the radiant intensity profile of the illuminator using the measurements.
37. (original) A process as described in Claim 36, wherein the projection lithography tool comprises a stepper, a one dimensional scanner, a two dimensional scanner, an EUV scanner, an EPL machine, or an image side immersion lens.

38. (original) A process as described in Claim 36, wherein the recording substrate comprises a silicon wafer, a flat panel, a circuit board, or a wafer mounted electronic sensor.

39. (original) A process for measuring the radiant intensity of an illuminator in a projection lithography tool comprising:

exposing a recording substrate with a multiple field in-situ imaging objective with sufficient resolution to permit reconstruction of a radiant intensity profile of an illuminator; and

reconstructing the radiant intensity profile of the illuminator using measurements of the exposed substrate.

40. (original) A process as defined in Claim 39, wherein the substrate is a silicon wafer.

41. (original) A process for measuring the radiant intensity of an illuminator beamtrain in a projection lithography tool, the process comprising:

loading a multiple field in-situ imaging objective with sufficient resolution to permit reconstruction of a radiant intensity profile of an illuminator into the projection lithography tool;

providing an electronic sensing array, wherein the electronic sensing array is in optical communication with the imaging objective;

exposing the electronic sensing array to an illuminator beamtrain through the imaging objective;

recording the electronic sensing array output; and

reconstructing the radiant intensity profile of the illuminator beamtrain using measurements of the sensing array.

SEP 13 2008

42. (currently amended) A process for producing a photolithographic chip mask work from a photolithography projection imaging system, the method comprising:
projecting a desired mask work reticle in the projection imaging system;

measuring the radiant intensity of an illuminator beamtrain in the projection lithography system by performing operations comprising:
loading a multiple field in-situ imaging objective with sufficient resolution to permit reconstruction of a radiant intensity profile of the illuminator beamtrain into a projection lithography tool of the projection imaging system;

exposing a recording substrate to multiple doses of light through the in-situ imaging objective;

developing the substrate and measuring the substrate to determine exposed regions versus dose; and

reconstructing the radiant intensity profile of the illuminator beamtrain using the measurements; and

controlling production of chip mask works through adjustment of projection imaging system in accordance with the reconstructed radiant intensity profile of the illuminator beamtrain.

43. (original) A process as described in Claim 42, wherein the projection lithography tool comprises a stepper, a one dimensional scanner, a two dimensional scanner, an EUV scanner, an EPL machine, or an image side immersion lens.

44. (original) A process as described in Claim 42, wherein the recording substrate comprises a silicon wafer, a flat panel, a circuit board, or a wafer mounted electronic sensor.

45. (original) A microelectronic chip production system comprising:
a production system controller that operates the system; and
a photolithographic projection imaging system comprising:

a scanning controller that controls a scanner of the projection imaging system;

a plurality of discrete imaging objectives, each capable of imaging to a corresponding field point, thereby imaging a plurality of field points wherein the plurality of discrete imaging objectives have sufficient resolution to permit reconstruction of a radiant intensity profile of an illuminator;

a common imaging surface for the plurality of discrete imaging objectives, wherein each of the plurality of field points is imaged on the common imaging surface;

a common mounting for the plurality of imaging objectives; and

a process controller that measures radiant intensity of a photolithographic illumination source in the photolithography projection imaging system and adjusts operation of the projection imaging system in accordance with the measured radiant intensity.

46. (original) A method of controlling a photolithographic projection scanner comprising:

exposing a recording substrate with a multiple field in-situ imaging objective wherein the multiple in-situ imaging objectives have sufficient resolution to permit reconstruction of a radiant intensity profile of an illuminator;

reconstructing the radiant intensity profile of the illuminator using measurements of the exposed substrate; and

adjusting the scanner in accordance with the reconstructed radiant intensity profile so as to minimize variations in the radiant intensity profile of the scanner.

47. (original) A method as defined in Claim 46, wherein the substrate comprises a semiconductor wafer.

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Preliminary Amendment

REMARKS


This Preliminary Amendment in the pending application provides amendments to the specification and claims, to correct obvious typographical and grammatical errors. No new matter has been added to the application.

Entry of the amendments and examination of the application on the merits are respectfully requested.

Any fees that may be due in connection with the filing of this paper, or during the entire pendency of this application, may be charged to Deposit Account No. 50-1213.

Respectfully submitted,
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